SMART FAN AND PUMP CONTROLLER

FIELD OF THE INVENTION

[0001] The present invention relates generally to the field of cooling technologies and more specifically to the field of cooling technologies within a device enclosure including cooling fans or pumps.

BACKGROUND OF THE INVENTION

[0002] As technology advances, more and more heat-generating electronic devices are packed into smaller and smaller enclosures. With most electronic devices, there is a critical temperature above, which the device or devices will no longer operate correctly. Currently there are a wide variety of methods used to cool electronic device enclosures including fans for air-cooling devices and liquid cooling techniques where a cooling liquid is pumped through the enclosure. As with most moving mechanical devices, these fans and pumps are subject to wear, causing their operating characteristics to change. Also, a fan or pump may be temporarily blocked by an obstruction, reducing the efficiency of the fan or pump. When these events occur, the cooling system may no longer operate sufficiently to keep the electronic devices being cooled within their operating temperature range. At this point the device may fail, causing expensive downtime for repairs to the fan or pump, and possibly expensive repairs to the electronic devices themselves.

[0003] Many DC fans are capable of operation for short times above their maximum rated voltage. While exceeding the maximum rated voltage may shorten the lifetime of a fan, it may be desirable to sacrifice fan lifetime in exchange for the prevention of

unscheduled down time. In most electronic systems, fan cost is a small fraction of the cost of the rest of the system. Typically fan cost is also small relative to the cost of unscheduled downtime for the system. Thus, in some situations, it is desirable to have the ability to apply higher voltages to a fan or pump to temporarily maintain necessary system cooling capability, while allowing a user to schedule time for repairing or replacing the fan or pump (if necessary) at a time convenient to the user. This would allow the system to avoid sudden unexpected system failures, and allows the system user more flexibility in scheduling repairs to the cooling system.

SUMMARY OF THE INVENTION

[0004] A pump or DC fan used to cool an electronic system is monitored for speed. When the pump or fan encounters an unexpected increase in impedance, such as an obstruction or a bearing anomaly, the controller temporarily increases the power to the pump or fan to overcome the impedance, and optionally notifies the user of the pump or fan problem. Also, when the pump or fan impedance returns to a normal range, the controller returns the power to the pump or fan to normal levels. In some embodiments, the controller may supply more power to the pump or fan than specified by the manufacturer to temporarily over come the increased impedance or pending failure of the pump or fan. This increased power allows the fan or pump to operate at a speed necessary for cooling an electronic system during a temporary increase in impedance, or during a slow degradation of the efficiency of the fan or pump.

[0005] Other aspects and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Figure 1 is a graph of fan speed of two different fans, one of which has an increase in impedance.

[0007] Figure 2 is a graph showing the reaction of the controller to a fan, which has an increase in impedance according to an example embodiment of the present invention.

[0008] Figure 3 is a view of a DC fan and controller according to an example embodiment of the present invention.

[0009] Figure 4 is a view of a pump and controller according to an example embodiment of the present invention.

[0010] Figure 5 is a flowchart of an example embodiment of the control of fan speed according to the present invention.

[0011] Figure 6 is a flowchart of an example embodiment of the control of pump speed according to the present invention.

[0012] Figure 7 is a flowchart of an example embodiment of the control of liquid flow speed according to the present invention.

DETAILED DESCRIPTION

[0013] Figure 1 is a graph of fan speed of two different fans, one of which has an increase in impedance. In this graph, the vertical axis **100** represents fan speed in revolutions per minute (rpm) increasing from bottom to top, and the horizontal axis **102** represents time increasing from left to right. The long dashed line **104** represents fan speed data for a normally operating fan. This normal fan operates near a fan speed of S1 **110**. The short dashed line **106** represents fan speed data for a fan that has an increase in impedance at time T1 **108**. This increase in impedance manifests itself in

a reduction in fan speed from speed S1 **110** to speed S2 **112** at time T1 **108**. In this example, the increase in impedance is permanent. The fan speed never recovers back to the normal speed S1 **110** but remains indefinitely at a slower speed S2 **112**. This type of failure may signal a bearing problem with the fan that will require the fan to be replaced. However, the problem is that the slower fan speed S2 **112** may not be sufficient to cool the electronic system it is associated with. Thus, the system may fail unexpectedly due to this inadequate cooling. By increasing the power to the fan, the system may be adequately cooled until it is convenient for the user to shut down the system and replace the fan instead of being faced with an unexpected system failure. Even if the increased power shortens the lifespan of the fan, it is to the user's benefit since the fan needed to be replaced anyway. Any extra time provided the user to gracefully shut down the system is invaluable.

[0014] Figure 2 is a graph showing the reaction of the controller to a fan, which has an increase in impedance according to an example embodiment of the present invention. This graph is similar to that of the failing fan from Figure 1, and includes the voltage applied to the failing fan along with the resulting corrected fan speed. Like Figure 1 this graph has a left vertical axis **100** representing fan speed in rpm increasing from bottom to top, and a horizontal axis representing time increasing from left to right. In addition, this graph has a right vertical axis **214** representing fan voltage in volts (V) increasing from bottom to top. There are three lines plotted on this graph. First the fan speed of the failing fan as shown in Figure 1 is represented by the short dashed line **106**. The voltage supplied by the controller to the failing fan is represented by the solid line **200** which is measured by the right vertical axis **214**. Finally the long dashed line **202** represents the fan speed of the failing fan as corrected by the present invention. This long dashed line **202** is measured by the fan speed left vertical axis

100. As in Figure 1 the fan speed of the failing fan decreases from a first speed S1 **206** to a second speed S2 **208** at a time T1 **204** representing an increase in impedance occurring at time T1 **204**. However, in this example embodiment of the present invention, the fan speed data is sent to a controller that responds to the decrease in fan speed by increasing the voltage supplied to the fan. Thus, at time T1 **204** the voltage supplied to the fan represented by the solid line **200** increases from a first voltage V1 **210** to a second voltage V2 **212**. In some embodiments of the present invention, this second voltage V2 **212** may be higher than the maximum rated voltage of the fan, thus shortening the lifespan of the fan, but allowing the user time to schedule maintenance of the system when convenient. Those of skill in the art will recognize that this technique also applies to cases where the control of pump speed is critical, and that similar techniques may be used to monitor pump speed and vary pump power in response to increases in pump impedance.

[0015] Figure 3 is a view of a DC fan and controller according to an example embodiment of the present invention. In this example embodiment of the present invention a DC cooling fan **300** including a motor **302**, fan blades **304** and power input connection **308** is configured to allow the capture of fan speed data. In some configurations the fan motor **302** itself supplies fan speed data **310** to a controller **314**. In other configurations a fan speed sensor **306**, such as an optical counter is used to send fan speed data **312** to the controller **314**. When an increased impedance manifests itself as a slower fan speed the controller **314** determines a voltage necessary to supply to the fan to return the fan speed to a normal speed and sends a control signal **316** to the power supply **318** that in turn, sends increased power through power conductors **320** to the fan **300**. Those of skill in the art will recognize that a wide variety of algorithms may be used within the controller **314** to actively

control the fan speed to a normal speed within the scope of the present invention. In some example embodiments of the present invention the controller **314** may also send a warning **322** to a user when the controller **314** increases fan voltage above a certain level.

[0016] Figure 4 is a view of a pump and controller according to an example embodiment of the present invention. Figure 4 is similar to Figure 3 except that the example embodiment of the present invention is used to control the speed of a pump. In this example embodiment of the present invention a rotary pump **400** is used to drive a liquid through a tube **402**. The speed of the pump **400** or the liquid within the tube **402** may be measured to determine the cooling efficiency of the system. In some example embodiments of the present invention pump speed data **410** may be sent from the pump **400** to a controller **412**. In other example embodiments of the present invention a flow detector **406** may send flow speed data **408** to the controller **412**. Still other example embodiments of the present invention may use both pump speed data **410** and flow speed data **408** to determine the proper power to supply to the pump **400**. The controller **412** determines a proper voltage or power level to supply to the pump **400** and sends a control signal **414** to the pump power supply **416**. When an increased impedance manifests itself as a slower pump speed or flow speed the controller **412** determines a voltage or power necessary to supply to the pump to return the pump speed or flow speed to a normal speed and sends a control signal **414** to the power supply **416** that in turn, sends increased power through power conductors **420** to the pump **400**. Those of skill in the art will recognize that a wide variety of algorithms may be used within the controller **412** to actively control the pump speed to a normal speed within the scope of the present invention. In some example embodiments of the present invention the controller **412** may send a warning **422** to a

user when the controller **412** increases pump power above a certain level. Those of skill in the art will recognize that this pump may be a compressor pump used in a cooling system where the compressor pump compresses a refrigerant. Pump speed may be monitored to detect any variations in impedance.

[0017] Figure 5 is a flowchart of an example embodiment of the control of fan speed according to the present invention. In a step **500**, the speed of a fan is monitored. In a decision step **502** if the fan speed is at a normal speed, control is passed back to step **500** to continue monitoring. If the fan speed is not at a normal speed, control is passed to a decision step **504**. In a decision step **504**, if the fan speed is below the normal speed, control is passed to step **506**. If the fan speed is above the normal speed, control is passed to step **510**. In step **510** the power supplied to the fan is decreased and control is passed back to step **500** to continue monitoring. In step **506** the power supplied to the fan is increased and in an optional step **508** a warning is sent to a user. Then control is passed pack to step **500** to continue monitoring.

[0018] Figure 6 is a flowchart of an example embodiment of the control of pump speed according to the present invention. In a step **600**, the speed of a pump is monitored. In a decision step **602** if the pump speed is at a normal speed, control is passed back to step **600** to continue monitoring. If the pump speed is not at a normal speed, control is passed to a decision step **604**. In a decision step **604**, if the pump speed is below the normal speed, control is passed to step **606**. If the pump speed is above the normal speed, control is passed to step **610**. In step **610** the power supplied to the pump is decreased and control is passed back to step **600** to continue monitoring. In step **606** the power supplied to the pump is increased and in an optional step **608** a warning is sent to a user. Then control is passed pack to step **600** to continue monitoring.

[0019] Figure 7 is a flowchart of an example embodiment of the control of liquid flow speed according to the present invention. In a step **700**, the flow speed of a liquid is monitored. In a decision step **702** if the flow speed is at a normal speed, control is passed back to step **700** to continue monitoring. If the flow speed is not at a normal speed, control is passed to a decision step **704**. In a decision step **704**, if the flow speed is below the normal speed, control is passed to step **706**. If the flow speed is above the normal speed, control is passed to step **710**. In step **710** the power supplied to the pump is decreased and control is passed back to step **700** to continue monitoring. In step **706** the power supplied to the pump is increased and in an optional step **708** a warning is sent to a user. Then control is passed pack to step **700** to continue monitoring.

[0020] The foregoing description of the present invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed, and other modifications and variations may be possible in light of the above teachings. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application to thereby enable others skilled in the art to best utilize the invention in various embodiments and various modifications as are suited to the particular use contemplated. It is intended that the appended claims be construed to include other alternative embodiments of the invention except insofar as limited by the prior art.